

CHAPTER 8

Using Nutrient Criteria To Protect Water Quality

Managing Point Source Pollution
Managing Nonpoint Source Pollution
Comprehensive Procedure for Nutrient
Management
Resources

This chapter provides an introduction to the applications of nutrient criteria. Chapter 1 described the ways in which nutrient criteria are used to (1) identify problems, (2) develop management plan, (3) assess regulations, (4) evaluate projects, and (5) determine the status and trend of the water resource. In this applications chapter, some of these are discussed in further detail. Section 8.1 addresses the management of point source pollution, in the context of standards development, National Pollutant Discharge Elimination System (NPDES) permits, and total maximum daily loads (TMDLs). Section 8.2 focuses exclusively on nonpoint source management programs. Although some material is not directly related to estuarine and coastal marine resources, it is included here because the coastal waters are the ultimate recipients of all drainage, both coastal and inland, and the information may be useful to a manager addressing various sources within a watershed. Coastal waters may, of course, be waters of the United States (see 40 CFR 122.2) and may thus be subject to the requirements of the Clean Water Act. Section 8.3 sets out a comprehensive planning, application, and evaluation procedure for estuarine and coastal marine nutrient quality management, and Section 8.4 lists publications on coastal/estuarine and watershed management and protection.

8.1 MANAGING POINT SOURCE POLLUTION

The term "point source" means any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged (CWA § 502(14)). This term does not include agricultural storm water discharges and return flows from irrigated agriculture. This section describes some of the programs relevant to point source discharges into rivers and streams.

The Clean Water Act and Water Quality Standards

The goals of the CWA are to achieve, wherever attainable, water quality that provides for protection and propagation of fish, shellfish, and wildlife and recreation in and on the water. The CWA further specifies that States adopt, and EPA approve, water quality standards consisting of designated uses, criteria to protect those uses, and an antidegradation policy (CWA section 303(c)). The criteria must be based on a sound scientific rationale and must contain sufficient parameters or constituents to protect the designated uses (40 CFR § 131.11(a)). For waters with multiple use designations, criteria must support the most sensitive use (Id.). Finally, in designating uses and establishing water quality criteria, States must ensure attainment of standards in downstream waters (40 CFR § 131.10(b)). With regard to nutrient criteria, Section 304(a) of the CWA directs EPA to develop and publish criteria that reflect the latest scientific knowledge of the effects of pollutants on biological community diversity, productivity,

and stability, including information on the factors affecting rates of eutrophication for varying types of receiving waters. In establishing water quality criteria, States should establish numeric values to protect designated uses based on EPA's Section 304(a) criteria guidance, modifications of the guidance recommendations reflecting site-specific conditions, or criteria based on other scientifically defensible methods (40 CFR § 131.11(b)(1)).

As illustrated in Figure 8-1, States adopt water quality standards for waters of the United States that comprise designated uses, criteria to protect those uses, and an antidegradation policy to protect existing water quality. Additionally, States develop implementation procedures to describe how the water quality standards will be applied. Once water quality standards are adopted and approved, they become the basis for legally enforceable NPDES permit limitations and a variety of assessment activities under the Clean Water Act.

Protecting Designated Uses

It has been amply demonstrated that nutrients are a major contributor to use impairment in waters of the United States. Because States are required to designate uses in consideration of the goals of the CWA and adopt criteria that contain sufficient parameters to protect designated uses, and because it is EPA's responsibility to make related recommendations, the Agency is developing and publishing Section 304(a) criteria for nutrients that provide for protection and propagation of fish, shellfish, and wildlife and recreation in and on the water.

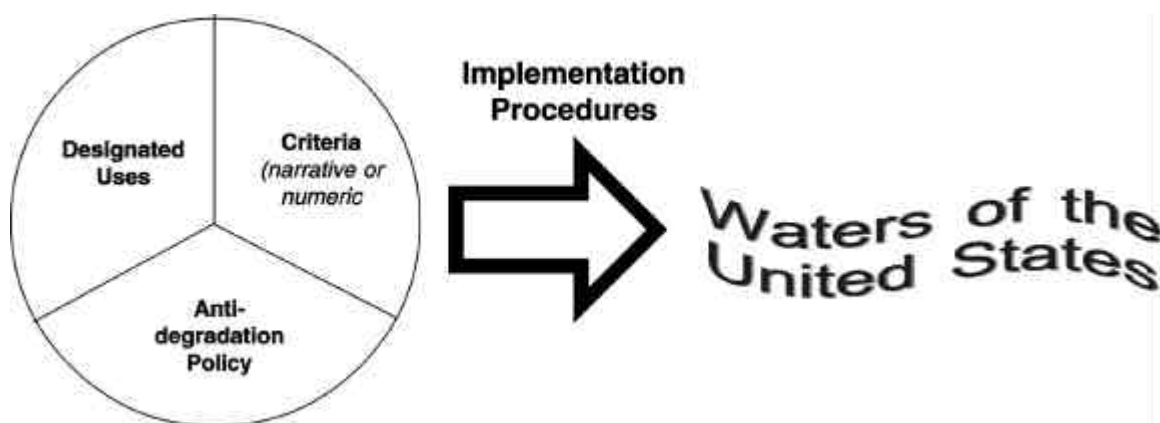


Figure 8-1. Components of water quality standards.

EPA's Section 304(a) criteria for nutrients are issued on the basis of ecoregion and waterbody type. This approach to nutrient criteria development provides a sound, scientifically defensible approach that accounts for the characteristics of different types and locations of waterbodies. EPA's ecoregional nutrient criteria are intended to represent enrichment conditions of surface waters minimally affected by human development. These criteria may be developed and further refined on the basis of the five elements described in this technical guidance manual.

Water quality criteria incorporating minimally affected (i.e., reference) conditions should provide for protection and propagation of aquatic life and recreation and reflect conditions that will not adversely affect the biological community. The parameters addressed in the Ecoregional Nutrient Criteria Documents are total phosphorus, total nitrogen, chlorophyll *a*, and turbidity (e.g., Secchi depth for lakes; turbidity for rivers and streams). These are the parameters that EPA considers important in nutrient assessment because the first two (nitrogen and phosphorus) are the main causal agents of enrichment, whereas the two response variables (chlorophyll *a* and turbidity) are indicators of system overenrichment for most surface waters.

Maintaining Existing Water Quality

Antidegradation

State and Tribal water quality standards include an antidegradation policy and methods through which the State or Tribe implements the policy. An antidegradation policy is required in State water quality standards to protect existing water quality. At a minimum, States must maintain and protect the quality of waters to support existing uses. Antidegradation implementation procedures address the measures used by States and Tribes to ensure that permits and control programs meet water quality standards and antidegradation requirements. The water quality standards regulation sets out a three-tiered antidegradation approach for the protection of water quality (40 CFR § 131.12).

Tier 1

Maintains and protects existing uses and the water quality necessary to protect these uses (40 CFR 131.12[a][1]). An existing use can be established by demonstrating that fishing, swimming, or other uses have actually occurred since November 28, 1975, or that the water quality is suitable to allow such uses to occur, unless there are physical problems, such as substrate or flow, that prevent the use from being attained (U.S. EPA 1994).

Tier 2

Protects the water quality in waters whose quality is better than that necessary to protect "fishable/swimmable" uses (40 CFR 131.12[a][2]). The water quality standards regulation requires that certain procedures be followed and certain showings be made (an "antidegradation review") before a point source is authorized to lower water quality in high-quality waters. In no case may water quality for a tier 2 waterbody be lowered to a level at which existing uses are impaired.

Tier 3

Outstanding national resource waters (ONRWs) are provided the highest level of protection under the antidegradation policy. The policy provides for protection of water quality in high-quality waters that constitute an ONRW by prohibiting the lowering of water quality. ONRWs are often regarded as highest quality waters of the United States: That is clearly the thrust of 131.12(a)(3). However, ONRW designation also offers special protection for waters of "exceptional ecological significance." These are waterbodies that are important, unique, or sensitive ecologically, but whose water quality, as measured by the traditional parameters such as dissolved oxygen or pH, may not be particularly high or whose characteristics cannot be adequately described by these parameters (such as wetlands).

The regulation requires water quality to be maintained and protected in ONRWs. EPA interprets this provision to mean no new or increased discharges to ONRWs and no new or increased discharge to tributaries to ONRWs that would result in lower water quality in the ONRWs. The only exception to this prohibition, as discussed in the preamble to the Water Quality Standards Regulation (48 FR 51402), permits States to allow some limited activities that result in temporary and short-term changes in the water quality of ONRW. Such activities must not permanently degrade water quality or result in water quality lower than that necessary to protect the existing uses in the ONRW. It is difficult to give an exact definition of "temporary" and "short-term" because of the variety of activities that might be considered. However, in rather broad terms, EPA's view of temporary is weeks and months, not years. The intent of EPA's provision clearly is to limit water quality degradation to the shortest possible time. If a construction activity is involved, for example, temporary is defined as the length of time necessary to construct the facility and make it operational. During any period of time when, after opportunity for public participation in the decision, the State allows temporary degradation, all practical means of minimizing such degradation shall be implemented. Examples of situations in which flexibility is appropriate can be found in the Water Quality Standards Handbook (U.S. EPA 1994).

General Policies

The water quality standards regulation allows States and Tribes to include implementation in their standards policies and provisions, such as mixing zones, variances, and low-flow exemptions (40 CFR § 131.13). Such policies are subject to EPA review and approval. These policies and provisions should be specified in the State's or Tribe's water quality standards document. The rationale and supporting documentation should be submitted to EPA for review during the water quality standards review and approval process.

Mixing Zones

States and Tribes may, at their discretion, allow mixing zones for dischargers. The water quality standards should describe the methodology for determining the location, size, shape, outfall design, and in-zone quality of mixing zones. Careful consideration should be given to the appropriateness of a mixing zone where a substance discharged is bioaccumulative, persistent, carcinogenic, mutagenic, or teratogenic.

Low-Flow Provisions

State and Tribal water quality standards should protect water quality for the designated and existing uses in critical low-flow situations. States and Tribes may, however, designate a critical low-flow below which numerical water quality criteria do not apply. When reviewing standards, States and Tribes should review their low-flow provisions for conformance with EPA guidance.

Water Quality Standards Variances

Variance procedures involve the same substantive and procedural requirements as removing a designated use (see 40 CFR 131.10 (g)), but unlike use removal, variances are both discharger and pollutant specific, are time-limited, and do not forego the currently designated use.

A variance should be used instead of removal of a use where the State believes the standard can ultimately be attained. By maintaining the standard rather than changing it, the State will assure that further progress is made in improving water quality and attaining the standard. With a variance, NPDES permits may be written such that reasonable progress is made toward attaining the standards without violating section 402(a)(1) of the Act, which requires that NPDES permits must meet the applicable water quality standards.

State variance procedures, as part of State water quality standards, must be consistent with the substantive requirements of 40 CFR 131. EPA has approved State-adopted variances in the past and will continue to do so if:

- Each individual variance is included as part of the water quality standard
- The State demonstrates that meeting the standard is unattainable based on one or more of the grounds outlined in 40 CFR 131.10(g) for removing a designated use
- The justification submitted by the State includes documentation that treatment more advanced than that required by sections 303(c)(2)(A) and (B) has been carefully considered, and that alternative effluent control strategies have been evaluated
- The more stringent State criterion is maintained and is binding upon all other dischargers on the stream or stream segment
- The discharger who is given a variance for one particular constituent is required to meet the applicable criteria for other constituents
- The variance is granted for a specific period of time and must be rejustified upon expiration but at least every 3 years (Note: the 3-year limit is derived from the triennial review requirements of section 303(c) of the Act.)

- The discharger either must meet the standard upon the expiration of this time period or must make a new demonstration of "unattainability"
- Reasonable progress is being made toward meeting the standards
- The variance was subjected to public notice, opportunity for comment, and public hearing. (See section 303(c)(1) and 40 CFR 131.20.) The public notice should contain a clear description of the impact of the variance on achieving water quality standards in the affected stream segment.

Providing Flexibility in Implementation

Abundant flexibility is built into the criteria-setting process and water quality standards regulations to allow States to (1) develop their own criteria to protect specific uses or reflect local conditions, (2) use different techniques to develop criteria as long as they are protective and scientifically defensible, and (3) conduct use attainability studies and refine their use designations.

States also have the flexibility to adopt numeric criteria to protect designated uses or adopt methods and procedures that "translate" narrative criteria into numeric values. Narrative criteria statements, often referred to as "general criteria" in States' standards regulations, usually take the form of a description of desired water quality condition or a preclusion of certain types of pollution or undesirable conditions (i.e., the "free from" provisions). Narrative criteria are considered critical backstops for designated use protection and are a powerful means of achieving desired water quality if they are interpreted in a clear and consistent manner. In water quality standards parlance, a "translator" is a process, methodology, or guide that States or Tribes use to quantitatively interpret narrative criteria statements. Translators may consist of biological assessment methods (e.g., field measures of the biological community), biological monitoring methods (e.g., laboratory toxicity tests), models or formulas that use input of site-specific information/data, or other scientifically defensible methods. Translators are particularly useful in describing water quality conditions that require a greater degree of sophistication to assess than typically can be expressed by numerical criteria that apply broadly to all waters with a given use designation. The translator may be either directly incorporated into State or Tribal water quality standards or incorporated by reference. In either case, specific limits or values for a measurable pollutant derived using a translator that interpret a narrative criterion statement should be attached to the State or Tribal regulations to ensure public review, as would be required of any site-specific numerical criterion.

States have the flexibility under current law to adopt appropriate nutrient criteria. If a State determines that its water quality criteria cannot be met, that State may consider refining use designation, adopting site-specific criteria, or issuing a variance to ensure that the appropriate uses and criteria to protect the uses are established. For example, if a regulated source faces expensive treatment to comply with a new or revised requirement, the State or Tribe can authorize a variance, based on a justification using one of the six factors at 131.10(g), to allow time for the discharge to come into compliance with a permit limit for the criteria and/or weigh options on treatment technologies, use reclassification, or site-specific development criteria as appropriate.

Water quality criteria guidance published by EPA under Section 304(a) of the CWA, such as for nutrients, serve as primary sources of information to States and Tribes as they develop numeric criteria as part of their water quality standards. Under the CWA and EPA's implementing regulations, States and Tribes also may use other information, including local water quality conditions, as they develop standards. Typically, EPA uses its own water quality criteria guidance as the principal basis for proposing and promulgating a replacement water quality standard when a State or Tribe fails to adopt an acceptable standard. In doing so, EPA commits to a process that includes public review and comment. EPA will solicit information from the public to determine if any such proposed Federal nutrient criteria for State waters are sufficiently protective of uses. This public process will help ensure that any promulgated Federal water quality standards are appropriately protective.

NPDES Permits

The CWA requires wastewater dischargers to have a permit establishing effluent limits on pollutant discharges. The regulations at 40 CFR 122.41 et seq. require these permits to specify monitoring and reporting requirements. More than 200,000 sources are regulated by the NPDES permits nationwide. These permits regulate household and industrial wastes that are collected in sewers and treated at municipal wastewater treatment plants. Permits also regulate industrial point sources and concentrated animal feeding operations that discharge into other wastewater collection systems or that have the potential to discharge directly into receiving waters. Permits regulate discharges with the goals of protecting public health and aquatic life and ensuring that every facility treats wastewater. Typical pollutants regulated by NPDES are "conventional pollutants" such as fecal coliforms or oil and grease from the sanitary wastes of households, businesses, and industries; and "toxic pollutants" including pesticides, solvents, polychlorinated biphenyls (PCBs), dioxins, and heavy metals that are particularly harmful to animal or plant life. "Nonconventional pollutants" are any additional substances that are not conventional or toxic that may require regulation, including nutrients such as N and P.

[Source: <http://www.epa.gov/owm/gen2.htm>]

Discharge monitoring data for pollutants limited and/or monitored pursuant to NPDES permits issued by States, Tribes, or EPA are required to be stored in the central EPA Permit Compliance System (PCS). The assessment of point source loadings is not a simple process of assessing PCS data, even though PCS is an important data source. The PCS database does not provide complete information for important N sources. Most PCS N data are generated by water quality-based permit limitations on ammonia, often applied in discharges to smaller streams. Few data exist in PCS on other forms of N, or TN; and data for TP is not frequently found in PCS. This situation exists largely because most permits do not include limits and/or monitoring requirements for N or P. The lack of nutrient limits and/or monitoring requirements in permits is due to a general lack of State water quality standards for these parameters.

[Source: <http://www.epa.gov/msbasin/protocol.html>]

The NPDES Storm Water Permitting Program

Storm water runoff is one of the remaining causes of contaminated lakes, streams, rivers, and estuaries throughout the country. Pollution in storm water runoff is responsible for closing beaches and shellfish harvesting areas, contaminating fish, and reducing populations of water plants and other aquatic life.

High flows of storm water runoff cause flooding, property damage, erosion, and heavy siltation. The 1987 Congressional Amendments to the Clean Water Act required EPA to control pollution from storm water discharges. In 1990, EPA promulgated Phase I regulations to control storm water discharges from municipal separate storm sewer systems (MS4s) serving populations of more than 100,000, construction activities disturbing more than 5 acres, and industrial facilities through issuance of NPDES storm water permits. EPA promulgated Phase II of the program in 1999 to control storm water discharges from MS4s less than 100,000 and small construction sites between 1 and 5 acres in size. The Phase II regulations also expanded the exemption for industrial facilities that do not have exposure of industrial activities and materials to storm water.

Construction Permits

The 1987 Congressional Amendments to the CWA required EPA to control pollution from storm water discharges. EPA issued a general NPDES permit for construction sites disturbing 5 or more acres in 1992. General permits provide EPA with an effective mechanism to regulate discharges from tens of thousands of construction sites, thus protecting and improving surface water quality across the Nation. Several general permits for construction activity have been issued/reissued since that first permit in 1992. EPA Regions 1, 2, 3, 7, 8, 9, and 10 have a general permit that authorizes the discharge of storm water associated with construction activity disturbing 5 or more acres and smaller sources as designated by the Agency on a case-by-case basis. This multiregional permit is known as the "Construction General Permit" (CGP).

Region 4 has issued a separate CGP for the State of Florida and Indian Country lands in Florida, Mississippi, Alabama, and North Carolina. Region 6 has also issued its own CGP for the States of Texas and New Mexico; Indian Country lands in Texas, New Mexico, Oklahoma, and Louisiana; and construction activity at oil, gas, and pipeline facilities in Oklahoma.

As used in these construction permits, the term "storm water associated with construction activity" refers to category (x) of the definition of "discharge of storm water associated with industrial activity," which includes construction sites and common plans of development or sale that disturb 5 or more acres (see 40 CFR 122.26 [b][14]). The CGP applies only to areas for which EPA is the permitting authority (certain States, Federal facilities, and Indian Lands). The majority of the country (i.e., 44 States and the Virgin Islands) has been granted authority for permitting storm water discharges and as such, each of these States is required to develop permits to control discharges from construction activities. In response to the Phase II regulations, permit applications from construction activities between 1 and 5 acres is required by March 2003.

Combined Sewer Overflows (CSOs)

Combined sewer overflows, or CSOs, can be a significant water pollution and public health threat in urban areas. EPA's 1994 CSO Control Policy is a comprehensive national strategy to ensure that cities, NPDES authorities, water quality standards authorities, and the public engage in a comprehensive and coordinated planning effort to implement cost-effective CSO controls that meet the objectives and requirements of the Clean Water Act.

During dry weather, combined sewer systems transport wastewater directly to sewage treatment plants. In periods of rainfall or snowmelt, however, the wastewater volume in a combined sewer system can exceed the capacity of the collection system or treatment plant. When this happens, combined sewer systems overflow and discharge untreated wastewater directly to streams, rivers, lakes, or estuaries.

It provides guidance to municipalities and State and Federal permitting authorities on meeting pollution control goals of the CWA in a flexible, cost-effective manner. Information on EPA's CSO Control Policy, accompanying guidance documents, and other elements of the national CSO control program can be found on the following website: <http://www.epa.gov/npdes.htm>.

Storm Water Planning

The Watershed Management Institute, Inc., recently published a new manual entitled *Operation, Maintenance, and Management of Stormwater Management Systems* (1998). This manual presents a comprehensive review of the technical, educational, and institutional elements needed to ensure that storm water management systems are designed, built, maintained, and operated properly during and after their construction. The manual was developed in cooperation with the EPA Office of Water to assist individuals responsible for designing, building, maintaining, or operating storm water management systems. It will also be helpful to individuals responsible for implementing urban storm water management programs.

The manual includes fact sheets on 13 common storm water treatment best management practices (BMPs) that summarize operation, maintenance, and management needs and obligations, along with construction recommendations. Other chapters review planning and design considerations, programmatic and regulatory aspects, considerations for facility owners, construction inspection, inspection and maintenance after construction, costs and financing, and disposal of storm water sediments. Forms for inspecting BMPs during construction and determining maintenance needs afterwards are included in the manual and in a separate supplement.

[Source: <http://www.epa.gov/owowwtr1/NPS/wmi/index.html>]

[Additional information: <http://www.epa.gov/owowwtr1/NPS/ordinance/osm6.htm> and <http://www.epa.gov/owowwtr1/info/NewsNotes/issue05/nps05sto.html>]

Total Maximum Daily Load (TMDL)

States, territories, and authorized Tribes establish section 303(d) lists of impaired waters based on information contained in their 305(b) reports as well as other relevant and available water quality data. The section 303(d) list is a prioritized list of waters not meeting water quality standards. States are required to submit lists biennially (40 CFR § 130.7(d)). States must develop TMDLs for waters and pollutants on their section 303(d) lists (CWA § 303(d)(1)(C)). State section 303(d) lists and TMDLs must be submitted to EPA for approval or disapproval. If EPA disapproves a list or TMDL submission, EPA must identify waters for the list or establish the TMDL itself (CWA § 303(d)(2)).

A TMDL is a written, quantitative plan and analysis for attaining and maintaining water quality standards in all seasons for a specific waterbody and pollutant. Specifically, a TMDL is the sum of the allowable

loads of a pollutant from all contributing point, nonpoint, and background sources (40 CFR § 130.2(i)). TMDLs may be established on a coordinated basis for a group of waterbodies in a watershed. TMDLs identify the loading capacity of the water, wasteload allocations (for point sources), load allocations (for nonpoint sources), and a margin of safety (U.S. EPA 1999) (40 CFR § 130.2), and are calculated at levels necessary to achieve applicable water quality standards (CWA § 303(d)(1)(C)).

A waste load allocation (WLA) is the proportion of a receiving water's TMDL that is allocated to point sources of pollution. Water quality models are often utilized by regulatory agencies in conducting an assessment to determine a WLA. Models establish a quantitative relationship between a waste load and its impact on water quality. WLAs are used by permit writers to establish Water Quality Based Effluent Limits (WQBELs).

[Source: http://www.epa.gov:80/owmitnet/permits/pwcourse/chapt_06.pdf]

Both the 1996 and 1998 section 303(d) lists, as well as more recent 305(b) reports, reflect similar patterns: sediments, nutrients, and pathogens are the top three causes of waterbody impairment.

[Source: <http://www.epa.gov/owowwtr1/tmdl/faq.html>]

Continuing Planning Process (CPP)

Each State is required to establish and maintain a continuing planning process (CPP) as described in section 303(e) of the CWA. A State's CPP contains, among other items, a description of the process that the State uses to identify waters needing water quality-based controls, the process for developing TMDLs, and a description of the process used to receive public review of each TMDL (40 CFR § 130.5 & 130.7(a) & (c)). Descriptions may be as detailed as the Regional office and the State determine is necessary to describe each step of the TMDL development process. This process may be included as part of the EPA/State Agreement for TMDL development.

[Source: <http://www.epa.gov/owowwtr1/tmdl/decisions/dec4.html>]

Look to the Future ... Pollutant Trading

Point and nonpoint source pollutant trading involves financing reductions in nonpoint source pollution in lieu of undertaking more expensive point source pollution reduction efforts. A trading program is intended to produce cost savings for point source dischargers while improving water quality. In order for a trading program to be viable, there should be a waterbody identifiable as a watershed or segment, as well as a measurable combination of point sources and controllable nonpoint sources. In addition, point source dischargers can be expected to trade for nonpoint source reductions if they perceive this as an alternative to upgrade facility treatment capabilities. In addition, there should be significant load reductions for which the cost per pound reduced for nonpoint source controls is lower than the cost for upgrading point source controls.

Such a program allows the private sector to allocate its resources to reduce pollutants in the most cost-effective manner, and it encourages the development of a watershed-wide or basin-wide approach to water quality protection. A pollutant trading program also requires cooperation between agencies and requires a system to arrive at trading ratios between point and nonpoint source controls.

For example, in a North Carolina watershed, the Tar-Pamlico Basin Association (a coalition of point source dischargers) and State and regional environmental groups have proposed a two-phased nutrient management strategy that incorporates point and nonpoint source pollutant trading. The plan requires association members to finance nonpoint source reduction activities in the basin if their nutrient discharges exceed a base allowance.

[Source: <http://www.epa.gov/OWOW/NPS/MMGI/funding.html#9>]

8.2 MANAGING NONPOINT SOURCE POLLUTION

During the first 15 years of the national program to abate and control water pollution, EPA and the States focused most of their water pollution control activities on traditional "point sources," such as discharges through pipes from sewage treatment plants and industrial facilities. These point sources have been regulated by EPA and the States through the NPDES permit program established by section 402 of the CWA. Discharges of dredged and fill materials into wetlands have also been regulated by the U.S. Army Corps of Engineers and EPA under section 404 of the Clean Water Act.

The Nation has greatly reduced pollutant loads from point source discharges and has made considerable progress in restoring and maintaining water quality as a result of the above activities. However, the gains in controlling point sources have not solved all of the Nation's water quality problems. Recent studies and surveys by EPA and by State/Tribal water quality agencies indicate that the majority of the remaining water quality impairments in our Nation's rivers, streams, lakes, estuaries, coastal waters, and wetlands result from nonpoint source pollution and other nontraditional sources, such as urban storm water discharges and combined sewer overflows.

Nonpoint source pollution generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification. Technically, the term "nonpoint source" is defined to mean any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the CWA, defined in the preceding section. Although diffuse runoff is generally treated as nonpoint source pollution, runoff that enters and is discharged from conveyances such as those described above is treated as a point source discharge and hence is subject to the permit requirements of the Clean Water Act. In contrast, nonpoint sources are not subject to Federal permit requirements.

The pollution of waters by nonpoint sources is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural pollutants and pollutants resulting from human activity, finally depositing them into lakes, rivers, wetlands, coastal waters, and groundwaters. Nonpoint source pollution can also be caused by atmospheric deposition of pollutants onto waterbodies. Furthermore, hydrologic modification is a form of nonpoint source pollution that often adversely affects the biological and physical integrity of surface waters. A more detailed discussion of the range of nonpoint sources and their effects on water quality and riparian habitats is provided in subsequent chapters of this guidance. A summary of State laws related to nonpoint source pollution can be found in the *Almanac of Enforceable State Laws to Control Nonpoint Source Water Pollution* (ELI 1988). This report can be accessed on the Internet at <http://www.eli.org/bookstore/research.htm>.

Nonpoint Sources of Nutrients

Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters (U.S. EPA 1993a) was developed by EPA for the planning and implementation of Coastal Nonpoint Pollution Programs. The guidance focuses on controlling five major categories of nonpoint sources that impair or threaten waters nationally. Management measures are specified for (1) agricultural runoff, (2) urban runoff (including developing and developed areas), (3) silvicultural (forestry) runoff, (4) marinas and recreational boating, and (5) hydromodification (e.g., channelization and channel modification, dams, and streambank and shoreline erosion). EPA guidance also includes management measures for wetlands, riparian areas, and vegetated treatment systems that apply generally to various categories of sources of nonpoint pollution. Management measures are defined in the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA) as economically achievable measures to control the addition of pollutants to waters, which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint pollution control practices, technologies, processes, siting criteria, operating methods, or other alternatives.

The following section outlines some of the management measures specified in the CZARA guidance for the various types of nonpoint sources. These measures should be considered when implementing programs targeting nutrient releases into waters of the United States.

Agricultural Runoff

- Erosion and sediment control
- Control of facility wastewater and runoff from confined animal facilities
- Nutrient management planning on cropland
- Grazing management systems
- Irrigation water management

Urban Runoff

- Control of runoff and erosion from existing and developing areas
- Construction site runoff and erosion control
- Construction site chemical control (includes fertilizers)
- Proper design, location, installation, operation, and maintenance of on-site disposal systems
- Pollution prevention education (e.g., household chemicals, lawn and garden activities, golf courses, pet waste, on-site disposal systems, etc.)
- Planning, siting, and developing roads, highways, and bridges (including runoff management)

Silvicultural Runoff

- Streamside management
- Road construction and management
- Forest chemical management (includes fertilizers)
- Revegetation
- Preharvest planning, harvesting management

Marinas and Recreational Boating

- Siting and design
- Operation and maintenance
- Storm water runoff management
- Sewage facility management
- Fish waste management
- Pollution prevention education (e.g., proper boat cleaning, fish waste disposal, and sewage pumpout procedures)

Hydromodification (i.e., channelization, channel modification, dams)

- Minimize changes in sediment supply and pollutant delivery rates through careful planning and design
- Erosion and sediment control
- Chemical and pollutant control (includes nutrients)
- Stabilization and protection of eroding streambanks or shorelines

Wetlands, Riparian Areas, Vegetated Treatment Systems

- Protect the NPS abatement and other functions of wetlands and riparian areas through vegetative composition and cover, hydrology of surface and groundwater, geochemistry of the substrate, and species composition
- Promote restoration of preexisting function of damaged and destroyed wetlands and riparian systems
- Promote the use of engineered vegetated treatment systems if they can serve a NPS pollution abatement function

Efforts To Control Nonpoint Source Pollution

Efforts to control nonpoint source pollution include nonpoint source management programs, the National Estuary Program, atmospheric deposition, coastal nonpoint pollution control programs, and Farm Bill conservation provisions. These efforts are described below.

Nonpoint Source Management Programs

In 1987, in view of the progress achieved in controlling point sources and the growing national awareness of the increasingly dominant influence of nonpoint source pollution on water quality, Congress amended the Clean Water Act to focus greater national efforts on nonpoint sources. In the Water Quality Act of 1987, Congress amended section 101, “Declaration of Goals and Policy,” to add the following fundamental principle:

It is the national policy that programs for the control of nonpoint sources of pollution be developed and implemented in an expeditious manner so as to enable the goals of this Act to be met through the control of both point and nonpoint sources of pollution.

More importantly, Congress enacted section 319 of the CWA, which established a national program to control nonpoint sources of water pollution. Under section 319, States address nonpoint pollution by

assessing nonpoint source pollution problems and causes within the State, adopting management programs to control the nonpoint source pollution, and implementing the management programs. Although not required, many States have incorporated the management measures specified in the 1993 CZARA guidance into their State Nonpoint Source Management Programs.

Section 319 also authorizes EPA to issue grants to States to assist them in implementing those management programs or portions of management programs that have been approved by EPA. As of FY 2000, more than \$1 billion in grants have been given to States, Territories, and Tribes for the implementation of nonpoint source pollution control programs.

For additional information on the Nonpoint Source Management Program and distribution of Section 319 grants in your State, contact your State's designated nonpoint source agency. For many States, the nonpoint source agency is the State Water Quality Agency. However, in several instances, other agencies or departments are given nonpoint source responsibility (see Table 8-1).

National Estuary Program

EPA also administers the National Estuary Program under section 320 of the CWA. This program focuses on point and nonpoint pollution in geographically targeted, high-priority estuarine waters. Under this program, EPA assists State, regional, and local governments in developing comprehensive conservation and management plans that recommend priority corrective actions to restore estuarine water quality, fish populations, and other designated uses of the waters. For additional information, contact your local estuary program. The following estuaries are currently enrolled in the program:

Table 8-1. States for which the nonpoint source agency is not the water quality agency

State	State Nonpoint Source Agency
Arkansas	State Department of Soil and Water Conservation
Delaware	State Department of Soil and Water Conservation
Oklahoma	State Department of Soil and Water Conservation
Tennessee	State Department of Agriculture
Texas	Department of Soil and Water Conservation (for agriculture) Texas Water Quality Board (all other nonpoint sources)
Vermont	State Department of Agriculture
Virginia	State Department of Soil and Water Conservation

- Albemarle-Pamlico Sounds, NC
- Barataria-Terrebonne Estuarine Complex, LA
- Barnegat Bay, NJ
- Buzzards Bay, MA
- Casco Bay, ME
- Charlotte Harbor, FL
- (Lower) Columbia River Estuary, OR and WA
- Corpus Christi Bay, TX
- Delaware Estuary, DE, NJ, and PA
- Delaware Inland Bays, DE
- Galveston Bay, TX
- Indian River Lagoon, FL
- Long Island Sound, NY and CT
- Maryland Coastal Bays, MD
- Massachusetts Bays, MA
- Mobile Bay, AL
- Morro Bay, CA
- Narragansett Bay, RI
- New Hampshire Estuaries, NH
- New York-New Jersey Harbor, NY and NJ
- Peconic Bay, NY
- Puget Sound, WA
- San Francisco Estuary, CA
- San Juan Bay, PR
- Santa Monica Bay, CA
- Sarasota Bay, FL
- Tampa Bay, FL
- Tillamook Bay, OR

Atmospheric Deposition

Even though runoff from agricultural and urban areas may be the largest source of nonpoint pollution, growing evidence suggests that atmospheric deposition may have a significant influence on nutrient enrichment, particularly from nitrogen (Jaworski et al. 1997). Gases released through fossil fuel combustion and agricultural practices are two major sources of atmospheric N that may be deposited in waterbodies (Carpenter et al. 1998). Nitrogen and nitrogen compounds formed in the atmosphere return to the earth as acid rain or snow, gas, or dry particles (<http://www.epa.gov/acidrain/effects/envben.html>). EPA has several programs that address the issue of atmospheric deposition, including the National Ambient Air Quality Standards, the Atmospheric Deposition Initiative, and the Great Waters Program.

National Ambient Air Quality Standards

The Clean Air Act provides the principal framework for national, State, and local efforts to protect air quality. Under the Clean Air Act, national ambient air quality standards (NAAQS) for pollutants that are considered harmful to people and the environment are established.

The Clean Air Act established two types of national air quality standards. Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings (<http://www.epa.gov/airs/criteria.html>).

Atmospheric Deposition Initiative

In 1995, EPA's Office of Water established an "Air Deposition Initiative" to work with the EPA Office of Air and Radiation to identify and characterize air deposition problems with greater certainty and examine solutions to address them. The Air and Water Programs are cooperating to assess the atmospheric deposition problem, conduct scientific research, provide innovative solutions to link Clean Air Act and Clean Water Act tools to reduce the of these pollutants, and communicate the findings to the public. To date, most efforts have focused on better understanding of the links between nitrogen and mercury

emissions and harmful effects on water quality and the environment. Significant work has also been done towards quantifying the benefits to water quality of reducing air emissions and developing sensible, cost-effective approaches to reducing the emissions and their ecosystem and health effects (<http://www.epa.gov/owow/wtr1/oceans/airdep/index.html>).

Great Waters Program

On November 15, 1990, in response to mounting evidence that air pollution contributes to water pollution, Congress amended the Clean Air Act and included provisions that established research and reporting requirements related to the deposition of hazardous air pollutants to the "Great Waters." The waterbodies designated by these provisions are the Great Lakes, Lake Champlain, and Chesapeake Bay. As part of the Great Waters Program, Congress requires EPA, in cooperation with the National Oceanic and Atmospheric Administration, to monitor hazardous pollutants by establishing sampling networks, investigate the deposition of these pollutants, improve monitoring methods, monitor for hazardous pollutants in fish and wildlife, determine the contribution of air pollution to total pollution in the Great Waters, evaluate any adverse effects to public health and the environment, determine sources of pollution, and provide a report to Congress every 2 years. These reports provide an information base that can be used to establish whether air pollution is a significant contributor to water quality problems of the Great Waters, determine whether there are significant adverse effects to humans or the environment, evaluate the effectiveness of existing regulatory programs in addressing these problems, and assess whether additional regulatory actions are needed to reduce atmospheric deposition to the Great Waters. For more detail, the Great Waters biennial reports to Congress discuss current scientific understanding of atmospheric deposition (<http://www.epa.gov/airprog/oar/oaqps/gr8water/xbrochure/program.html>).

Coastal Nonpoint Pollution Control Programs

In November 1990, Congress enacted CZARA. These amendments were intended to address several concerns, a major one being the impact of nonpoint source pollution on coastal waters.

To address more specifically the impacts of nonpoint source pollution on coastal water quality, Congress enacted section 6217, "Protecting Coastal Waters," which was codified as 16 USC-1455b. This section provides that each State with an approved coastal zone management program must develop and submit a Coastal Nonpoint Pollution Control Program for EPA and National Oceanic and Atmospheric Administration (NOAA) approval. The purpose of the program "shall be to develop and implement management measures for nonpoint source pollution to restore and protect coastal waters, working in close conjunction with other State and local authorities."

States with Coast Nonpoint Pollution Control Programs are required to include measures in their programs that are "in conformity" with the 1993 CZARA guidance, as discussed previously. A listing of States with Coastal Nonpoint Pollution Control Programs is presented in Table 8-2. For additional information on the programs in these States, contact the State water quality agency.

Table 8-2. States and Territories with coastal nonpoint pollution control programs

Alabama	Maine	Oregon
Alaska	Maryland	Pennsylvania
American Samoa	Massachusetts	Puerto Rico
California	Michigan	Rhode Island
Connecticut	Mississippi	South Carolina
Delaware	New Hampshire	Virgin Islands
Florida	New Jersey	Virginia
Guam	New York	Washington
Hawaii	North Carolina	Wisconsin
Louisiana	Northern Mariana Islands	

Farm Bill Conservation Provisions

Technical and financial assistance for landowners seeking to preserve soil and other natural resources is authorized by the Federal Government under provisions of the Food Security Act (Farm Bill). Provisions of the 1996 Farm Bill relating directly to installation and maintenance of BMPs are summarized in the following sections. Contact your Natural Resources Conservation Service (NRCS) State Conservationist's office for State-specific information.

Environmental Conservation Acreage Reserve Program (ECARP)

ECARP is an umbrella program established by the 1996 Farm Bill and contains the Conservation Reserve Program (CRP), Wetlands Reserve Program (WRP), and Environmental Quality Incentives Program (EQIP). It authorizes the Secretary of Agriculture to designate watersheds, multi-State areas, or regions of special environmental sensitivity as conservation priority areas eligible for enhanced Federal assistance. Assistance in priority areas is to be used to help agricultural producers comply with NPS pollution requirements of the CWA and other State or Federal environmental laws. The ECARP is authorized through 2002.

Conservation Reserve Program (CRP)

First authorized by the Food Security Act of 1985 (Farm Bill), this voluntary program offers annual rental payments, incentive payments, and cost-share assistance for establishing long-term, resource-conserving cover crops on highly erodible land. CRP contracts are issued for a duration of 10 to 15 years for up to 36.4 million acres of cropland and marginal pasture. Land can be accepted into the CRP through a competitive bidding process through which all offers are ranked using an environmental benefits index, or through continuous signup for eligible lands where certain special conservation practices will be implemented.

The Conservation Reserve Enhancement Program (CREP) is a new initiative of CRP authorized under the 1996 Federal Agricultural Improvement and Reform Act. CREP is a joint, State-Federal program designed to meet specific conservation objectives. CREP targets State and Federal funds to achieve

shared environmental goals of national and State significance. The program uses financial incentives to encourage farmers and ranchers to voluntarily protect soil, water, and wildlife resources.

Wetlands Reserve Program (WRP)

The WRP is a voluntary program to restore and protect wetlands and associated lands. Participants may sell a permanent or 30-year conservation easement or enter into a 10-year cost-share agreement with USDA to restore and protect wetlands. The landowner voluntarily limits future use of the land, yet retains private ownership. The NRCS provides technical assistance in developing a plan for restoration and maintenance of the land. The landowner retains the right to control access to the land and may lease the land for hunting, fishing, and other undeveloped recreational activities.

Environmental Quality Incentives Program (EQIP)

The EQIP was established by the 1996 Farm Bill to provide a voluntary conservation program for farmers and ranchers who face serious threats to soil, water, and related natural resources. EQIP offers financial, technical, and educational help to install or implement structural, vegetative, and management practices designed to conserve soil and other natural resources. Current priorities for these funds dictate that one-half of the available monies be directed to livestock-related concerns. Cost-sharing may pay up to 75% of the costs for certain conservation practices. Incentive payments may be made to encourage producers to perform land management practices such as nutrient management, manure management, integrated pest management, irrigation water management, and wildlife habitat management.

Wildlife Habitat Incentives Program (WHIP)

This program is designed for parties interested in developing and improving wildlife habitat on private lands. Plans are developed in consultation with NRCS and the local Conservation District. USDA will provide technical assistance and share up to 75% of the cost of implementing the wildlife conservation practices. Participants generally must sign a 5- to 10-year contract with USDA that requires they maintain the improvement practices.

Forestry Incentives Program (FIP)

Originally authorized in 1978, the FIP allows cost sharing of up to 65% (up to a maximum of \$10,000 per person per year) for tree planting, timber stand improvement, and related practices on nonindustrial private forest land. The FIP is administered by NRCS and the U.S. Forest Service. Cost share funds are restricted to individuals who own no more than 1,000 acres of eligible forest land.

Conservation of Private Grazing Land

This program was authorized by the 1996 Farm Bill for providing technical and educational assistance to owners of private grazing lands. It offers opportunities for better land management, erosion reduction, water conservation, wildlife habitat, and improving soil structure.

Cooperative Extension

State land grant universities and Cooperative Extension play an important role in management implementation. They have the expertise to research, transfer, and implement agriculture management systems that will be needed to meet nutrient criteria. In addition, they have developed models and other predictive management tools that will aid in selecting the most appropriate management activities. Contact your local Cooperative Extension Agent or the Agriculture Department at a State land grant university for more information on the services they can provide.

8.3 COMPREHENSIVE PROCEDURE FOR NUTRIENT MANAGEMENT

Numeric water quality criteria adopted by States into their water quality standards can also serve as effective scientific tools for comprehensive water and land resource management. Effective programs incorporate aspects of prevention and maintenance as well as restoration. It is important that existing high-quality waters be managed wisely as a public resource, and waters whose uses are not yet threatened or impaired, but nonetheless are at risk from ongoing pollution, should be identified and managed so that designated uses are maintained in the future. The following 10-step management program that originated with the Wisconsin Inland Lakes Program (Gibson et al. 1983) has since been refined to become a natural resources management approach with utility for any water resource. States and Tribes can use this approach in addition to established regulatory protocols. Though intended to protect or enhance coastal marine or estuarine waters, the program does not, however, establish or replace any mandated procedures as part of a regulatory requirement.

Management of tidal and marine waters may be approached as a rational progression of actions beginning with a statement of major stressors and symptoms and progressing logically to a course of action and final assessment to determine the relative success of the effort. The following steps illustrate this management approach. States or communities are encouraged to adapt this technique to suit their particular needs and expectations. Where considerable information is already available, some of these steps may be skipped, but the methodology is presented here in detail for consideration.

Step 1: Status Identification

Data used during the preliminary nutrient criteria development process and the application of the criteria will present the resource manager with the general status of the estuary or coastal area and the need for responsive action. The information associated with these efforts, however, usually indicates a broad status condition, for example, high nutrient concentrations, algal blooms, fish kills, loss of seagrasses, or low-dissolved oxygen. Available data should be evaluated carefully to tease out potential connections to land use practices or recent changes in practices (e.g., development, fishing pressure, stocking or lack thereof). In particular, previous investigations should be reviewed to make a preliminary determination of anthropogenic cause(s) as opposed to natural cycling of the system. Trend assessments on the Chesapeake Bay, for example, are based on 10-year intervals in an effort to distinguish seasonality from cultural impacts. Essentially, a preliminary evaluation of readily available data is necessary to ascertain that there is indeed a problem or potential problem brought on by nutrient overenrichment and that the sources of the threat probably can be addressed to the betterment of these waters and the public good.

Step 2: Background Investigation

Given that the initial information reveals a viable management concern, it then becomes necessary and justifiable to gather as much background information as possible about the waters in question. There are three primary sources of such information.

Literature Searches

The initial effort here should be a search of the "gray literature" (often internal regional State and Federal agency reports that provide specific information about the relevant waters). Sources of such information include natural resource and fisheries agencies, forestry services, water quality administrations, hydrological and geological survey offices, planning offices, multi-State or county commissions, and community or environmental groups. A second source to comb through is peer-reviewed professional literature journals and related publications such as proceedings of conferences and symposiums, which may include specific studies of the estuary or coastal region of concern. The primary value of this source, however, probably will be discussions of methods and techniques of investigation and management. As the management investigation progresses, these sources of information become more pertinent.

Questionnaires

In preparing a list of agencies from which reports may be solicited, the names of key personal contacts should emerge. These contacts are the biologists, chemists, specialists, academics, resource managers, and citizen activists most familiar with these waters. As the literature and baseline data are reviewed, particular questions should develop, the answers to which will provide a fuller understanding of the resource and lend direction to the investigation and eventual management plan. Particularly helpful will be an understanding of the historical antecedents of the present status of the waters.

A standardized questionnaire can be prepared listing concerns such as the availability of any reports or data or understanding of the history of development in the watershed, perhaps including industries, agricultural practices, or development and structures associated with the resource. Particular episodes may be noted for comment in the questionnaire, such as hurricanes, fish kills, algal blooms, or spill events, as well as historical problems, such as marina development, port facilities, spoils disposal sites, agricultural runoff, erosion problems, or development concentrations.

All discharge sites should be documented, such as industrial discharges, "Superfund sites," wastewater treatment plants, drains, concentrations of housing with onsite wastewater treatment, marinas, major road crossings, and tributaries potentially bearing large loadings of sediments or nutrients. Problem land use areas along the shore also should be noted, for example, degraded wetlands, embayments where blooms or fish kills regularly occur, or areas where seagrasses recently have contracted. In addition, it is helpful to include a large, fairly detailed line drawing of the estuary or portion of the estuary or coastal reach and its proximal watershed that the respondent may use to reference particular observations.

If at all possible, the questionnaire should be limited to no more than two pages of questions, including space for answers plus the line drawing. Questions should be direct and concise. Determine exactly

what you wish to learn and ask questions specifically related to this information. Opportunities for additional comments should include an open-ended question at the end of the questionnaire.

To get the best response to a questionnaire, the potential respondents should be called first to confirm their mailing addresses and availability. They should be advised of the nature of the study and their cooperation then requested. Other potential respondents may be identified through these calls. If a large survey is necessary, this preliminary step may not be possible. Most regional inquiries, however, are made usually to no more than 50 specialists, and the additional information gained is well worth the telephone calls.

Interviews

By this point in the background investigation process, the key people to contact for detailed information should be evident. Their names will have come up in conversations and on reports, and they will be the people providing the most helpful responses on the questionnaires.

Other valuable contacts are Basin Commissions; Interstate and State management agencies; EPA, NOAA, and U.S. Fish and Wildlife Service specialists; the USDA Cooperative Extension Service agents for the area; State, county, and municipal planners; and university faculty. Long-term residents and commercial as well as sport fishermen and their organizations should be contacted also. Anecdotal information can be invaluable and helps add perspective to other sources of data.

The interviews should assess the questionnaire data gathered already; they should clarify and elaborate on the basic information generated. The interviews also are the means by which apparent contradictions in perceptions or observations may be resolved at least partially. It should be noted that many people are uncomfortable with recorded interviews; note-taking often is less intimidating. In either case, immediately after each interview, a record of answers and observations should be prepared while the impressions of the interviewer are still fresh.

The information compiled from each background investigation should clarify further the initial problem stated. It should help resolve any ambiguities about the dynamics of the system and the human community. In addition, the compilation should identify areas where more definitive, primary data collection is required to clearly understand the nutrient problems of a particular waterbody and provide direction for the subsequent management project.

Step 3: Data Gathering and Diagnostic Monitoring

Data obtained during the nutrient criteria development process are the mainstay of the database to be prepared for any subsequent investigation. The intent of such a process is to develop a reasonable image of the status of the estuary, bay, or coastal region. Diagnostic monitoring should expand on that structure and extend the understanding from status of the resource to a diagnosis of causes of the overenrichment. For example, where several tributaries of an estuary or salinity zone have been sampled and two are identified as being of concern, they and other higher order feeder streams must now be sampled to further target the locations of probable loadings. Though earlier sampling was done to portray the enrichment

state of the waters, subsequent sampling should focus on near-shore areas of potential loadings, tributaries, and portions of the tributaries where loadings may originate.

Diagnostic monitoring supports the identification of water quality problems and helps to develop an appropriate management plan. General guidelines for conducting diagnostic monitoring are as follows.

Parameters To Sample

Diagnostic monitoring is conducted after nutrient criteria have been established. It might not be necessary, therefore, to sample some parameters that are not related to the criteria.

- Diagnostic sampling for nutrients requires an estimation of nutrient loading and sources. Major potential sources of nutrients (e.g., tributary streams, groundwater flow, runoff, illegal discharges, atmospheric deposition) should be identified and sampled in such a way as to obtain an estimate of annual loads from each source.
- The variables and techniques employed in the preliminary survey should be reviewed for adequacy and either repeated or augmented. A manager should not eliminate the basis of the original classification by dropping any variables or stations at this point. Documenting potential success or failure of the subsequent management program will require "before" and "after" databases, and the initial survey design should be modified only after careful consideration and due attention to reestablishing the baseline survey.

Flow measurements also are an essential part of this survey. Perhaps more important than in any other water resource investigation, attention to tidal state and amplitude and seasonal hydrologic characteristics is imperative to determining the extent and source of nutrient loadings to estuaries and coastal marine waters. If nutrient concentrations are to be compared meaningfully and loading estimates made, cross-sectional areas and flow rates for all tributary streams and discharges also must be included in the survey design. These measurements must be made or extrapolated whenever water quality samples are collected. Without this information, assigning priorities to various loading sources identified in the investigation will be difficult or impossible.

Sampling Frequency

Sampling frequency will increase for diagnostic monitoring because the sample population is now a particular area of the waterbody. Sampling should occur repeatedly during the growing season to precisely characterize individual areas as well as discharges and loadings. Statistical power analysis can be used to determine the appropriate sample size based on the purpose of the sampling and the acceptable error (see Chapter 5).

In addition to expanding the number of stations and parameters to accommodate diagnostic determinations, the survey design should address temporal variables by sampling these stations during each season of the year at times calibrated to the particular climate and locale. Accommodation may be needed for periods of base flow, maximum runoff, turnovers, periods of maximum and minimum

productivity, and, in some instances, migratory patterns of fish or waterfowl. Seasonal changes in land use such as peak summer or winter vacation periods, agricultural applications and harvests in the watershed, and seasonal commercial or industrial activities also should be addressed.

To separate signals from seasonal "noise," it may be necessary to gather survey data for 2 or more consecutive years to strengthen data assessment (as noted above, some estuary management programs survey over as many as 10 years, requiring an extensive operating budget). Such assessments will require a robust statistical evaluation of the data; this element should be incorporated into the study design at the outset. As with the initial survey design, the preliminary statistical tools chosen may be carried into this subsequent design as well. Care should be taken to replicate sample collections to ensure representative sample design and confidence in the results obtained. Early inclusion of a skilled environmental statistician on the management team is advisable.

Sampling Location

If turbidity, nutrients, and algae are known to be variable across the surface of an estuary or salinity zone, then multiple sample sites within that zone are required. The exact number of sampling sites in a zone is determined by the spatial variability of nutrients, turbidity, and chlorophyll and the desired precision. In general, within a basin or zone, variation in time is larger than variation in space (Knowlton and Jones 1989). Thus, chlorophyll samples taken 2 weeks apart may differ severalfold, but samples taken on the same day 500 meters apart are likely to differ much less. Depending on the questions being addressed in the investigation, spatially composite samples may be more cost-effective than separate samples from several sites.

The design and placement of these sample stations will rely heavily on the proximal and watershed land use information garnered from the background investigation. The overall objective should be to bracket suspected sources of nutrient loadings in the tributaries and near-bank areas so parcels can be either selected or eliminated as potential candidates for management attention.

Step 4: Source Identification

The cumulative information gathered should now provide a clear image of the state of the estuarine or coastal segment, the most likely sources of nutrient loadings or related degradation, and their relative contributions to the problem. It is important to note that this process reveals only local sources of the overenrichment. Atmospheric deposition of nitrogen compounds and other broad-scale impacts beyond the watershed scale are not specifically addressed and must be assumed as essentially an environmental constant. With all the risks this constant entails, it is probably not an undue assumption; remediation of such depositions is probably beyond the scope of most nutrient management projects employing this guidance.

The problems to be identified are likely to be as diverse as the geology, hydrology, and land use practices of the waterbody and watershed. Typical developments include sediment resuspension and nutrient re-release; biotic imbalances affecting nutrient utilization caused by overfishing or stock mismanagement; discharge of excess nutrients directly to the waters by wastewater treatment plants,

storm water runoff, or failing septic systems; and runoff from municipalities, subdivisions, farms, commercial enterprises, and industrial activities. Other problems have included concentrations of migratory and resident waterfowl contributing to an excess of nutrients, removal or filling of bank areas and wetlands that once intercepted nutrient runoff, runoff of herbicide applications that killed macrophytes and promoted nuisance algal blooms, and chronic, low-dissolved oxygen problems attendant to overenrichment and vegetative imbalances.

Any combination of these in situ and land use problems can cause a cumulative overenrichment problem. Management planning requires identifying first the loading sources and, second, of those sources, the ones that are most significant. Proximity of a source to a lake or reservoir (or in some cases, the ubiquitous nature of a source throughout a watershed such as subdivision or farm runoff), the relative loading estimate of that source, and the likelihood of successful remediation are the key factors in deciding which problem sources are priorities for inclusion in a management plan.

Loading estimation models are valuable for estimating the relative significance of various nutrient sources in the watershed with respect to the likely response of the waters. Chapter 9 describes many of these models and their relative utility. Modeling permits a manager to try out various scenarios and combinations of techniques to estimate their likely effectiveness. Some of these options for a nutrient management plan are discussed in the next step.

Step 5: Management Practices for Nutrient Control

Once the major sources of concern are identified and agreed on by the management planners, remedial measures appropriate to these sources must be identified. Management practices are well defined and documented for a variety of land uses in EPA guidance documents, USDA manuals, U.S. Forest Service manuals, and urban land use planning guides. Resource managers should study these references for likely approaches to consider and then consult regional experts in each of the subject land uses for qualification and other suggested management practice recommendations. Bringing these specialists together as a small workgroup is an effective, although sometimes contentious, way to develop the most technically sound approaches to such problems.

Fitting the various components together in a comprehensive management plan is challenging. It calls for both imagination and cooperation. Usually no one approach stands out as the obvious best choice. Instead, two or three permutations of several generally agreed on BMPs will evolve from the planning sessions.

Selection of the optimal approach—or more likely, the best candidates—should first involve careful assessment by the planning workgroup and then consultation with all elements of the watershed community, both organized interest groups and private landowners. The first phase should be conducted using the threefold framework of evaluation developed by the Department of Resource Development at Michigan State University (Figure 8-2). The premise behind this approach holds that the most effective and achievable management plan should address three elements of practicality: scientific validity, sociopolitical consideration, and economic consideration.

- No resource or environmental management plan should be considered unless it is scientifically valid. The technology proposed should be based in sound science and tested and validated. No attempt to manipulate the environment and peoples' land use prerogatives should be made unless it can be demonstrated in advance that the technique is reliable or at least that the risks are quantifiable and understandable.
- The proposed approach should be cost-effective and affordable by the community. Among technically sound plans to achieve desired goals, the most cost-effective (typically those with elements that have the greatest benefit-cost ratios) are the easiest to implement and most likely to satisfy the public interest.
- The management plan should have adequate social and political acceptability. A plan that seems rational and cost-effective may conflict with the collective values of the local public. Any action taken in addition to existing requirements should always be researched carefully for justification, efficacy, lead time required, and likely effects on various segments of the community.

The resource manager most likely to achieve success will consider and responsibly address each of these three elements. All candidate alternatives should be evaluated in this manner and revised as necessary.

Such evaluation not only generates the optimal plan (or plans where competing but different strengths are evident), but documents the rationale, essential for public review before the final selection is made.

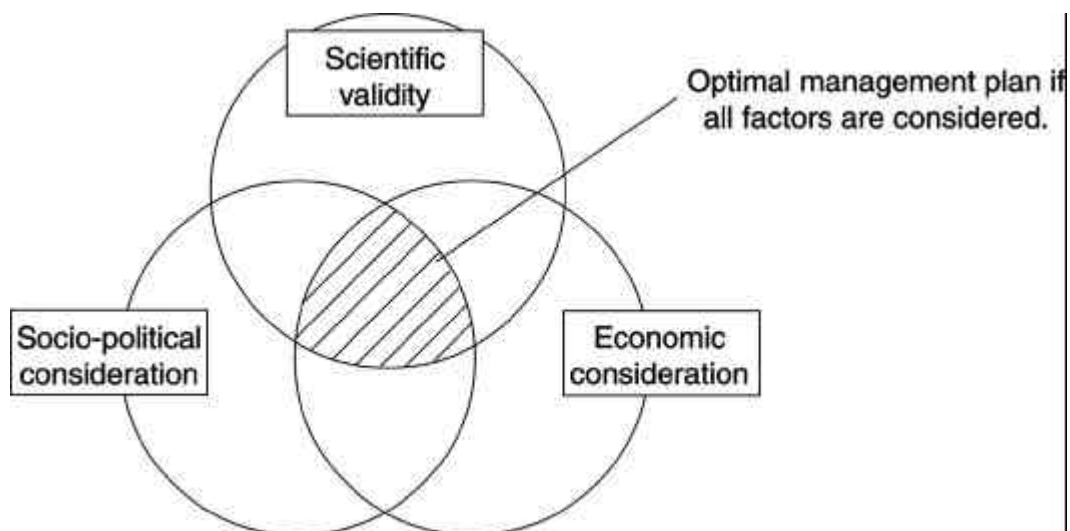


Figure 8-2. “Threefold framework” of evaluation.

Involving the public in the process throughout is highly beneficial, and invitations to meetings or advisories to all potentially interested parties should be provided regularly, if not from the outset then certainly before plan selection and approval are needed. A balance must be struck between making public announcements too early, which could arouse people before sufficient information has been generated, and making announcements too late, which may lead to suspicions that information is being withheld from the public.

Step 6: Detailed Management Plan Development

A detailed management plan should include all 10 steps of the process described here. The first five steps are necessary to achieve the design of the plan, but they also should be included so that anyone reading it will understand what has gone into the effort.

Natural resource management efforts can include one or more of these three elements: education, financing, and regulation; it is best to initiate them in the order presented here. Start with relatively low-cost information and education efforts to acquaint people with the problem and how you propose to address it, and to obtain their suggestions and perceptions. A good educational effort should be the incentive for volunteer agreements and cooperative action. A grant-in-aid or other assistance often is the key element to encourage individuals or jurisdictions to adopt appropriate water resource protection practices. Regulatory actions are necessary and appropriate when mandated by law, when cooperation and compliance are unlikely to occur otherwise, and when voluntary efforts have not succeeded.

Step 7: Implementation and Communication

Periodic progress reports during implementation of the management project are opportunities to communicate with administrators, other involved agencies, politicians interested in the project, the general public and landowners, and other interest groups. Progress reports should be brief and candid. They will be part of the public record so that all parties are properly informed, the post-project cry of inadequate notification is avoided or at least minimized, and techniques and methods used are documented.

Regional public meetings and hearings are excellent ways to communicate. The more controversial an issue, the more communication is necessary. To continue implementing a plan despite significant opposition without evaluating the consequences is a mistake, especially if a change to a step in the management plan with additional public consultation would still achieve the same objective.

Step 8: Evaluation Monitoring and Periodic Review

The management plan should always include "before, during, and after" water resource quality monitoring to demonstrate the responses of the system to management efforts. This is the reason for maintaining and expanding the initial survey stations. Monitoring data are important for evaluating progress and are included in the requisite progress reports described above. The change or lack thereof in the status of the estuarine or coastal waters is the ultimate determination of management success.

These built-in monitoring schedules should include seasonality and periodic data assessment intervals for management review to permit responses to changing circumstances, modifications of methods, schedules, and changes of emphasis as needed.

Step 9: Completion and Evaluation

Management projects are frequently planned, initiated, and concluded and even new initiatives undertaken to meet pressing schedules without sufficient evaluation of the initial project.

Reviews of progress reports, of the original objectives, and of the monitoring data will reveal whether the lake or reservoir trophic state was successfully protected or improved. Evaluation also provides documentation for determining whether the project's methods and techniques can be applied elsewhere, perhaps with modification. Finally, it will reveal any mistakes that should be avoided in future projects and perhaps will demonstrate that a sequel project is required to fully accomplish the original objectives.

Step 10: Continued Monitoring of the System

The monitoring initiated and expanded in the course of the project can now be reduced to periodic measuring of key variables at critical times and locations. The purpose now is to keep sufficiently informed of the status of the waters to ensure that the protection or remediation achieved is maintained. If periodic evaluation monitoring indicates a return of trophic decline, intervention should be possible at an early point so that costs of preserving that which was achieved are reduced. These evaluation and periodic monitoring steps essentially complete the process. If new issues arise, the manager returns to Step 1 with a new problem statement. General guidelines associated with evaluation monitoring are provided below.

Parameters To Sample

Each water quality parameter discussed in the Indicators chapter—TP, TN, chlorophyll *a*, Secchi depth, and dissolved oxygen as well as perhaps selenium and vegetation and indicator organisms—should be sampled during maintenance monitoring. Because the purpose of maintenance monitoring is to determine if conditions have changed or if criteria are exceeded, other physical or chemical variables need not be measured.

Sampling Frequency

Sampling efforts for maintenance monitoring can be adaptive and sequential, so that a certain minimum of information is collected at regular intervals, and if data indicate change or uncertainty, the sampling effort (in both time and space) can be increased to attempt to reduce the uncertainty. For example, a station in an undisturbed area could be sampled once every 5 years, from a single visit during an index period (say, midsummer). If results suggest a change in conditions beyond what is normally expected for these waters, then additional and more frequent sampling can be continued to determine if the departure from "normal" conditions is real and if it is ecologically significant. If TP, TN, chlorophyll *a*, and Secchi depth relationships have been established, it may be cost-effective to use Secchi depth as a preliminary indicator; if a trigger value is detected, more parameters can be measured.

Such variation also suggests different levels of maintenance monitoring, depending on existing knowledge of the waters and expectations. Maintenance monitoring may be done for several purposes:

- Routine monitoring of waters of known quality (i.e., sampled before) that are not expected to change greatly
- Initial sampling of a station of unknown quality
- Monitoring of a station or stations of known quality expected to change, say, as the result of watershed development or restoration efforts

Routine monitoring of stations of known quality is the least intensive and typically requires sampling once every several years, as in the example above. However, initial sampling of an estuary or coastal area of unknown quality requires the same sampling effort, and parameters, as the classification survey. Monitoring a known estuary or portion of an estuary or coastal area that is expected to change or suspected to have changed requires more intensive effort, typically an increase in sampling frequency to several times during the growing season, to obtain seasonal averages of indicator values.

The actual frequency of sampling should be determined by the number of samples required to detect an ecologically relevant change in the indicators, resources available for the monitoring program, and amount of time for a change to be detected. These considerations require power analysis using existing or preliminary data, and tradeoffs of desired significance level, desired power, desired effect size that is detectable, ecological significance, and most important, resources (labor and money) available for the monitoring program.

Sampling Location

For routine monitoring, it is recommended that the sampling locations be at least the same as for the classification survey to provide the database with a certain minimum continuity.

8.4 RESOURCES

Listed below are selected publications concerning coastal or estuarine and watershed management and protection.

- National Research Council. 2000. Clean Coastal Waters - Understanding and Reducing the Effects of Nutrient Pollution. National Academy Press. Washington, DC.
- Gibson, G. R., M.L. Bowman, J. Gerritsen, and B.D. Snyder. 2000. Estuarine and Coastal Marine Water Bioassessment and Biocriteria Technical Guidance. EPA 822-B-00-024. U. S. Environmental Protection Agency; Office of Water; Washington, DC.

- Sharpley, AN, ed. 2000. Agriculture and phosphorus management: the Chesapeake Bay. Boca Raton, FL: Lewis Publishers.

This text is a compilation of conference proceedings describing nutrient dynamics in the watershed of Chesapeake Bay, with emphasis on agricultural loadings and practices. Although directed at an estuarine environment, much of the agriculturally based nutrient information has broad application.

- U.S. Environmental Protection Agency. 1993. Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. EPA-840-B-92-002.

The EPA Office of Water produced the 1993 guidance document to support the Coastal Zone Act Reauthorization Amendments of 1990. This document describes several management measures to control nonpoint sources of pollution, including nutrients.

- U.S. Environmental Protection Agency. 1995. Watershed Protection: A Project Focus. EPA 841-R-95-003.

This document focuses on developing watershed-specific programs or projects. It provides a blueprint for designing and implementing watershed projects, including references and case studies for specific elements of the process. The document illustrates how the broader principles of watershed management, including all relevant Federal, State, Tribal, local, and private activities, can be brought to bear on water quality and ecological concerns.

- U.S. Environmental Protection Agency. 1995. Watershed Protection: A Statewide Approach. EPA 841-R-95-004.

This document is primarily designed for State water quality managers. A common framework for a statewide watershed approach focuses on organizing and managing a State's major watersheds (called basins in this document). In this statewide approach, activities such as water quality monitoring, planning, and permitting are coordinated for multiple agencies on a set schedule within large watersheds or basins.

- U.S. Environmental Protection Agency. 1997. Monitoring Consortia: A Cost-Effective Means to Enhancing Watershed Data Collection and Analysis. EPA 841-R-97-006.

This document addresses coordination in watershed monitoring. As demonstrated in the document's four case studies, consortia can stretch the monitoring dollar, improve cooperation among partners, and increase sharing of expertise as well as expenses of data collection and management.

- U.S. Environmental Protection Agency. 1997. Land Cover Digital Data Directory for the United States. EPA 841-B-97-005.

Land cover, which is the pattern of ecological resources and human activities dominating different areas of the Earth's surface, is one of the most important data sources used in watershed analysis and the management of water resources throughout the country. The 75 land cover data summaries in this directory include contact information to assist readers who may want to acquire copies of the digital data for their own use.

- U.S. Environmental Protection Agency. 1997. Designing an Information Management System for Watersheds. EPA 841-R-97-005.

This document is an introduction to the information management responsibilities and challenges facing any watershed group. The document reviews the fundamentals of identifying information management needs, integrating different databases, evaluating hardware and software options, and developing implementation plans.

- U.S. Environmental Protection Agency. 1997. Information Management for the Watershed Approach in the Pacific Northwest. EPA 841-R-97-004.

This document centers on a series of interviews with leaders and key participants in the statewide watershed approach activities in the State of Washington. The document reviews Washington's statewide watershed activities in case study fashion.

- U.S. Environmental Protection Agency. 1998. Inventory of Watershed Training Courses. EPA 841-D-98-001.

This inventory provides one-page summaries of 180 watershed-related training courses offered by Federal and State agencies; it also lists resource professionals in the private sector.

- U.S. Environmental Protection Agency. 1997. Statewide Watershed Management Facilitation. EPA 841-R-97-011.

This document addresses statewide watershed management and the process of facilitating the development or reorientation of statewide watershed programs. It includes State case histories.

- U.S. Environmental Protection Agency. 1996. Watershed Approach Framework. EPA 840-S-96-001.

This publication revisits and updates EPA's vision for a watershed approach, first explained in a 1991 document entitled "Watershed Protection Approach Framework." It describes watershed approaches as coordinating frameworks for environmental management that focus public and private efforts to address the highest priority problems in defined geographic areas, involving both ground and surface water flow.

- U.S. Environmental Protection Agency. 1997. Top 10 Watershed Lessons Learned. EPA 840-F-97-001.

Watershed work has been going on for many years now, and this 60-page document summarizes the top lessons that have been learned by watershed practitioners across the United States regarding what works and what does not.

- U.S. Environmental Protection Agency. 1999. Catalog of Federal Funding Sources for Watershed Protection (second ed.). EPA 841-B-99-003.

Many sources of Federal funding are available to support different aspects of watershed protection and specific types of local-level watershed projects. This document presents information on 52 Federal funding sources (grants and loans) that may be used to fund a variety of watershed projects.

- U.S. Environmental Protection Agency. 1997. Watershed Training Opportunities. EPA 841-B-97-008.

This is a 22-page booklet developed to highlight watershed training opportunities offered by EPA's Office of Water and the Watershed Academy. It covers training courses and educational materials on watersheds produced throughout the EPA Office of Water.

- U.S. Environmental Protection Agency. 1997. Stream Corridor Restoration: Principles, Processes and Practices. EPA 841-R-97-011.

This document is a practical reference manual and logical framework to help environmental managers recognize stream restoration needs and design and implement restoration projects.

- U.S. Environmental Protection Agency. 1997. Protocol for Developing Nutrient TMDLs. EPA 841-B-99-007.

This protocol is an organizational framework for the TMDL development process for nutrients. It leads to an understandable and justifiable TMDL.